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The Cryosphere Discussions

Interactive comment on "Speedup and fracturing of George VI Ice Shelf, Antarctic Peninsula" *by* T. O. Holt et al.

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The authors thank M. Pelto for his insightful and constructive comments on the discussion paper. We respond to each comment below.

SC-MP 1.) The paper does not discuss basal crevasses. Luckman et al. (2012) made a strong case for their importance as both structural weaknesses and having associated surface features evident in satellite imagery. The identification of the basal crevasses surface representation in their Figure 5, look very similar to several of the features in your Figure 5. The authors here are not focusing on identifying the source of either fractures or rifts, but should mention the potential relation to basal crevasses.

AC: Indeed, recent work of Luckman et al. (2012) and McGrath et al. (2012) has shown the important of basal crevasses on the Larsen C Ice Shelf, and it is likely that some of the surface undulations identified here as surface fractures relate to basal conditions. As you mention, here we do not attempt to differentiate between the different fracturing mechanisms, but we agree that there should be some recognition of their potential existence; this is now shown in Section 4.2.2, 5.1.2 and in Table 1.

SC-MP 2.) The delineation of fractures versus rifts has left me unsure of the efficacy of the distinction used for fractures. In the literature rifts are often used for features that do not penetrate the entire ice shelf, possibly because this is difficult to discern. Glasser and Scambos (2008) examining Larsen B, put together a detailed table for features that lacks fractures. In Glasser et al (2011) examination of the Prince Gustav Ice Shelf fractures are not part of the structural terminology. Braun et al (2009) in describing features of the Wilkins Ice Shelf refer repeatedly to fractures as small, but leading to rift development. MacGregror et al (2012) also use rifts not fractures for the ice shelves of the Amundsen Sea. Luckman et al (2012) similarly use rifting instead of fracturing for Larsen C. The large rifts in Pine Island Glacier do not penetrate the ice shelf and are referred to as rifts. The current large rift on Pine Island Glacier can be seen to reach the water line, according to Operation Icebridge, though they cannot determine if it penetrates the entire ice shelf. Many of the features in Figure 5 that are labeled as fractures I have seen labeled as rifts in other papers. In Figure 9 rifts and fractures are treated as a continuum, suggesting the difficulty of distinguishing. This is a minor point to be sure, but one that needs further clarification for readers to better understand the reason for establishing fractures as category of ice shelf structural features.

AC: This is a very interesting point and highlights, more than anything, that there is no accepted terminology for ice-shelf structures, partly due to the fact that it is difficult to distinguish between a rift that penetrates the entire depth of an ice shelf (following the definition used in Khazendar and Jenkins, 2003), from one that penetrates to the water line only. Here we wanted to differentiate between those rifts that do reach the water line from those that do not, thus terming those that don't as 'fractures'. In response to your comment here, and that of Ted Scambos (see Short Comment #2), we have revised our labelling strategy; all previous rifts and fractures are now termed 'rifts' in the revised paper, but we now distinguish between those that contain water or ice melange from those that don't, as we think it's important to highlight the differences between rifts that show evidence of reaching the water line to those that do not.

SC-MP 3.) 375-22: After mentioning structural weakness, should rifting formation and propagation be specifically referred to as part of this?

AC: We take 'structural weakening' to mean the initial development, propagation and advection of rifts into the ice shelf due to a change in the glaciological conditions, either along the suture zones as observed during the collapse of Larsen B, or due to an increase in extensional flow, as observed here. We do not think that specifically mentioning the process of rifting here adds anything significant to the point being made at this stage.

SC-MP 4.) 378-5: Hence, there is limited volume loss due to surface ablation, correct?

AC: There is likely to be some surface run-off, particularly along the Alexander Island grounding zone and through the numerous ice dolines that exist across the surface of GVIIS, but the majority of the meltwater will refreeze in the austral winter, then melt the following season, etc. So yes, there is limited mass lost through surface melting, and we have clarified this in Section 2.2.

SC-MP 5.) 385-19: I have submitted an annotated version of Figure 5. The upper left panel in this figure needs to be lightened. I am uncertain why the apparent rifts are not labelled as such, for the longitudinal features near B. These rifts do penetrate well into the ice from the margin and are zones of weakness and should not really be identified as the margin. The feature at Point A is not identified but is evident in the 1973 panel. The transition from features noted as fractures to rifts near Point C is where I am unclear if fractures is the correct term. In the 2010 image why are the features at the orange arrows not labeled rifts.

AC: The authors agree that the upper-left panel was too dark in the discussion paper and has since been lightened in the revised paper. With regards to the ‘rifts’ that you mention: those near ‘B’ are not rifts, but surface troughs that represent former flow unit boundaries. They become more distinct towards the ice front due to ice-shelf thinning. Indeed, these are structural weaknesses, and rifts do propagate along their length, but they are not rifts caused by extensional flow as described elsewhere. The feature you highlighted near ‘A’ is a faint surface undulation accentuated by the contrast stretch applied to the imagery, and is not what we would term a distinct ‘rift’. Rifting does take place near here ca. 1996 (SAR imagery, not shown), and this surface undulation is likely to have been exploited during the rifting phase, but in both the 2003 and 2010 images, the surface undulation is still clearly visible alongside the newly formed rift that makes up the ice front. The comment regarding Point C has been addressed elsewhere. As for the locations you highlighted in the 2010 panel, the feature along SIF1 is clearly a rift, but first and foremost is the ice front margin. The feature you highlight along SIF2 is again a product of a flow-unit boundary; indeed, there is a rift beginning to exploit this suture zone, and again this forms part of the ice front and has hence been labelled as such; as a result, no changes have been made to Figure 5 other than those previously mentioned.

SC-MP 5.) 390-25: This observation is almost identical to that which has been made for the thin floating tongue of Petermann Glacier, Greenland.

AC: The authors thank M. Pelto for this observation. It’s interesting to see a similar response in Greenland as we see in Antarctica, and indeed we’re curious about the structural response of marine-terminating glaciers in Greenland to environmental changes.

Interactive comment on The Cryosphere Discuss., 7, 373, 2013.